

## **RESULTS FROM PRIOR SUPPORT**

### **Planning Grant for the Development of A New Mexico EPSCoR Program**

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Since the award of a one-year planning grant on December 15, 2000, we have developed the organizational management structure for NM EPSCoR with the Council of University Presidents as the umbrella organization and the University of New Mexico as the fiscal institution, and have identified the State EPSCoR Committee and its chairperson, the State Director, and Co-Director. The State Committee analyzed the strengths and weaknesses in our research and educational efforts, and identified appropriate focus areas for the NM EPSCoR program. The State Committee solicited proposals and selected projects for this infrastructure proposal. Many meetings, discussions, and electronic communications have facilitated statewide communication and collaboration on scientific/education issues among academic institutions, offices of state government, federal laboratories, and private industry. We have targeted our state legislators, state government, and statewide industry groups to gain their support for our NM EPSCoR program. With their enthusiastic response to these collaborative efforts, we can develop a truly statewide effort to increase the state's competitive capabilities. Support from legislators and the Governor's Office will lead to state financial support in upcoming legislative sessions.

## **PROJECT DESCRIPTION**

### **The Role and Vision of New Mexico EPSCoR**

In New Mexico, we have the opportunity to create a productive synergy between our unique communities, our rich natural environment, and our high technology resources. Commercial business ventures, national laboratories, and institutions of higher education can unite with our ethnically diverse population in efforts to secure technological advancement, environmental sustainability, and economic growth. Education and research are the twin engines driving our state's economic growth and scientific and technological advances. NM EPSCoR will enable us to reach beyond our present capabilities to compete for private and federal resources through the collaborative efforts of our institutions.

New Mexico's great beauty attracts many visitors, yet its per capita income ranked 48<sup>th</sup> out of 50 from 1997-1999. New Mexico desperately needs to grow new businesses to create an economy and quality of life to match its natural beauty. NM EPSCoR can stimulate this development. Any economic enhancement, however, is dependent on our natural resource base, and managing those resources, especially water, requires increased innovative collaborations among all stakeholders.

The wide ethnic diversity of New Mexico requires special attention to incorporate all students into our academic and economic system. The majority (60%) of New Mexico's children (under 18) are Native American or Hispanic. Training and developing a sophisticated labor pool hinges on a diverse yet coordinated program targeting K-16 students by providing instructors and students with a rich research experience and education in emerging technologies. NM EPSCoR will provide research and training in cutting-edge science and technology and a competitive job environment in New Mexico. While New Mexico is well known for its federally funded national laboratories, Sandia (SNL) and Los Alamos (LANL), the state's universities actually rank fourth from the bottom with only a 2.46% gain in federal funding of science and engineering research from 1992 to 1999. From 1991 through 2000, not only were New Mexico universities about 45% below the national average for the number of competitive proposals submitted to the NSF, but also the state's successful proposal rate decreased in the last decade ([www.unm.edu/~nmepscor](http://www.unm.edu/~nmepscor)).

NM EPSCoR provides the mechanism that will bring together industry, academic, and national laboratory research groups. These collaborative efforts will establish a dynamic climate for building the state's internal industrial base and attracting new high tech industries to New Mexico, and increase our universities' ability to attract and retain faculty that can compete effectively for research funding.

### **Current Science and Technology Infrastructure**

Institutions currently involved in this NM EPSCoR proposal are:

- Research universities: *University of New Mexico* (UNM, Albuquerque; 24,250 students), *New Mexico*

*State University* (NMSU, Las Cruces; 14,958 students), *New Mexico Institute of Mining and Technology* (NMT, Socorro; 1,511 students).

- Four-year colleges: *Eastern New Mexico University* (ENMU, Portales; 3,617 students), *New Mexico Highlands University* (NMHU, Las Vegas; 3,095 students), and *Western New Mexico University* (WNMU, Silver City; 3,074 students).
- Two-year colleges: *San Juan College* (SJC, Farmington; 6,630 students, 27% Native American) and *Diné College*, a tribal college (Shiprock; 1,900 students, 99% Native American).

Widely distributed over the state, these institutions all devote some faculty and student time to research. Additionally, the national laboratories and several other federal labs/institutes can enhance academic units with their resources and expertise. More detailed college/university descriptions are available on the NM EPSCoR website ([www.unm.edu/~nmepscor](http://www.unm.edu/~nmepscor)).

### **Addressing Barriers to Progress in Science and Technology**

Despite New Mexico's rich natural and human resources and its interest in promoting new research, the NM EPSCoR State Committee has identified barriers both to nationally competitive research and to related educational and economic development. We lack:

- *Critical Mass*--The concentration of intellectual capital necessary to compete for large interdisciplinary/multidisciplinary programs does not exist at many of the universities.
- *Educated Workforce*--Higher education, national laboratories, and private industry have all expressed concern about the lack of a scientifically- and technologically-literate workforce.
- *Communication*--Private industry has not yet built an inclusive statewide communication infrastructure, particularly *Internet 2* connections, for our broadly dispersed population centers.
- *State Support*--A modest tax base limits the state funding for education, research, and economic development.
- *State-of-the-Art Research Instrumentation*--The difficulty in obtaining non-federal matches for expensive, state-of-the-art instrumentation limits research at many of our institutions.

### **New Mexico EPSCoR Focus Areas**

After analyzing the strengths and weaknesses of New Mexico's science and technology infrastructure, the State Steering Committee has targeted three immediately valuable focus areas: ***Natural Resource Analysis and Management***, ***Nanoscience***, and ***Proteomics***. These areas take advantage of unique capabilities in the state not fully utilized by universities (e.g., national laboratories), and address important environmental areas influencing economic development (e.g., water). These focal area disciplines, developing rapidly with federal and private funding, are important to the state's economy. To develop and maintain successful research in these areas, however, we need to upgrade statewide network connections and develop a scientifically and technically rich educational system.

### **NATURAL RESOURCE ANALYSIS AND MANAGEMENT**

We will establish a state *Institute for Natural Resource Analysis and Management* (INRAM). During the first three years, researchers, scientists, and staff will focus on water, biodiversity, and land management, aspects often poorly understood, yet crucial to New Mexico's environmental health. As a decentralized, collaborative venture of new and existing laboratories and museums, INRAM will address local problems with statewide expertise. With widely available equipment and expertise, INRAM will ensure that investigators at all institutions have access to the most modern technology. Moreover, data generated and made available by INRAM will enhance and promote research in ecology, evolution, systematics, geography, and hydrology.

### **Managing New Mexico's Water Resources**

Hydrology in New Mexico is difficult to understand and manage because of extremely high spatial variability that prevents us from measuring and modeling the hydrologic cycle. High variation in spatio-temporal patterns of rain, mountain snow packs and melt, soil moisture, surface runoff and erosion, and groundwater recharge contribute to the environmental complexity and data needs. At present, we measure water cycling at a series of heavily monitored sites, but these point measurements do not provide

adequate spatially distributed information. Remote sensing data and expertise are essential to spatial-temporal analysis.

#### ***Proposed Work***

NM EPSCoR will support the hire of an assistant professor in hydrology at NMT who will specialize in applying remotely sensed data to problems of water cycling in semiarid environments, and will conduct a statewide interactive TV seminar on the application of remote sensing data to hydrologic problems. INRAM will also establish a *Laboratory of Environmental Spatial Analysis* (LESA), described in a later section, to focus on environmental analysis using GIS and remote sensing technologies.

#### **Biodiversity**

New Mexico, rich in biodiversity, houses more species of terrestrial mammals than any other similarly sized area of non-tropical North America, and the vascular plant flora contains nearly 3,000 indigenous species. The arthropod fauna is similarly diverse, but poorly understood. Invasive species threaten many areas. Our knowledge of New Mexico's biodiversity is based on past biotic surveys and the specimens those surveys deposited in the state's natural history museum collections. Contrary to a national trend of reducing or eliminating museums, New Mexican professors and curators have wisely maintained and strengthened museum collections, invaluable records of the biota of New Mexico. Their wisdom has been validated by the current emphasis in biology on documenting and preserving biodiversity. However, to realize the collections' true value, we must develop modern digital archives, incorporating the data into a statewide GIS, increasing access of natural resource/land managers to these data, and relating biodiversity to other forms of environmental data.

#### ***Proposed Work***

INRAM will facilitate the integration of university museum data into a searchable geospatial format accessible via the LESA website. This database, along with new biotic surveys of plants, vertebrates, insects, and fungi will enhance our understanding of long-term biodiversity changes. New biotic surveys will include the collection of organismal tissues to be stored in ultra-cold freezers, financed by NM EPSCoR, for future analysis of genetic variation and phylogenetic relationships. Molecular genetic facilities at NMSU and UNM will participate in the analysis of genetic biodiversity. The Director of the Museum of Southwestern Biology at UNM will oversee the Biodiversity component of INRAM assisted by new collections managers at NMSU, UNM, and WNMU funded initially by NM EPSCoR. New hires by NMSU in plant systematics and by UNM in herpetology and mammalogy will further support the biodiversity preservation effort. The INRAM biodiversity initiative will improve New Mexico's competitiveness in the areas of systematics, biodiversity, and climate change studies.

#### **Land Management**

Maintaining healthy ecosystems requires accurate scientific information and its application by land use managers. Ecoinformatics is a broad interdisciplinary science that facilitates the understanding, generation, processing, and propagation of information and knowledge about humans and the environment. It is a rapidly advancing field that is critical for managing, analyzing, and interpreting the vast amounts of data that are being generated as a result of "instrumenting the environment," as well as addressing public and environmental health issues, land and water management, climate change, loss of biodiversity, and related societal issues. For example, forests cover about 850,000 hectares of land in New Mexico and represent the main economic resource of many rural communities. These forests are important watersheds providing the state with most of its fresh water and much of its biodiversity. Recent devastating wildfires near LANL afford an opportunity to compare the consequences of a wind-driven ponderosa pine forest fire (Cerro Grande) to a fuel-driven spruce-fir forest fire (Vivash), to re-examine how forests regenerate after catastrophic fires, and to assess the influence of invasive species in forest restoration efforts. Research efforts will identify proactive steps to minimize fire damage on the forest/urban interface. Fire database development and associated ecoinformatics activities will enable more effective management of the data volume necessary for effective land management.

#### ***Proposed Work***

INRAM will work with the state climatologist, universities, and state and federal agencies to

integrate currently available statewide databases on soil, climate, vegetation, and animal populations into an easily retrievable system available through LESA. These databases will be presented graphically using GIS and in a form to allow their use in models. These models will evaluate the response of ecosystems to different management decisions and will permit managers to make more informed judgments.

Particularly, NM EPSCoR will facilitate the collaboration between UNM, LANL, and NMHU in the development of ecoinformatics for the study of forests and regeneration after fires. NMHU, proximal to both recent major forest fire areas and LANL, will hire another tenure-track faculty member with expertise in forest ecology. LANL and UNM will develop the database and ecoinformatics for Cerro Grande fire-recovery research.

### **Laboratory of Environmental Chemistry**

Environmental chemistry, a technically sophisticated field, provides important mechanistic insights into hydrology, biodiversity, and ecosystems. However, New Mexico currently lacks a centralized facility where researchers and others can have soil, water, and biological samples analyzed using cutting-edge technology; we must routinely send samples out of state for analysis, thus hindering research in ecosystems, soils, hydrology, plant-insect interactions, and biodiversity.

#### ***Proposed Work***

INRAM will create a *Laboratory for Environmental Chemistry* (LEC) in the NMSU Department of Biology, which already houses a respected research group in environmental studies and biogeochemistry. The LEC will permit hands-on training in environmental chemistry and will broaden the range of research questions that can be addressed by environmental scientists statewide. Directed by faculty and a PhD-level technician, this facility will be equipped to prepare and analyze samples for their metal and mineral contents, measure stable isotope profiles, identify environmental toxins and pollutants, and isolate and characterize organic compounds.

### **Laboratory for Environmental Spatial Analysis (LESA)**

Successful integration, management, and analysis of environmental data on biodiversity, hydrology, and forests necessitate the development of an integrated, statewide accessible, well-equipped laboratory for spatial analysis capable of synthesizing high-quality data products. LESA will be located in and staffed by the NMSU Geography Department under the supervision of the Chair. The department has expertise in remote sensing and GIS data collection, georeferencing, and analysis. LESA will be linked with ecoinformatics capabilities at UNM, LANL, SNL, and NMHU to further provide researchers and managers with an easily accessible site for data, assistance, and training in spatial analysis.

#### ***Proposed Work***

LESA will have four related missions:

- *Primary Data Acquisition*--In addition to data collected by INRAM, remote sensing data will be acquired, enhanced, and classified in cooperation with NMSU's Center for Agricultural Remote Sensing and Meteorology and with UNM's Earth Data Analysis Center (EDAC). Near real time data provided by LESA and by unique satellite instruments (multispectral thermal imagery) from SNL and LANL will enable rapid-response capabilities.
- *Data Cataloging and Dissemination*--Both existing and newly obtained hydrology, biodiversity, environmental, and land use/land cover data will be collected and made available through LESA and EDAC. LESA will create a cataloging system that allows web-based access by thematic and geographic search methods for users to identify, share, and retrieve New Mexico environmental data by topic or by geographic region.
- *Data Analysis and Synthesis*--LESA will focus on environmental analysis using GIS and Remote Sensing technology. LESA staff will synthesize data products from INRAM in support of scientific and resource management activities within New Mexico.
- *Professional Outreach*--LESA will provide outreach to the state's university and tribal college research communities, and state and federal agencies through GIS and remote sensing training, distance education, and the INRAM website.

The statewide team collaborating on the INRAM project involves UNM, NMSU, NMT, NMHU,

ENMU, WNMU, LANL, SNL, Diné College, and the New Mexico Museum of Natural History and Science. The 3-year budget for this project is ~\$3M from NSF and ~\$1.9M matching.

## **NANOSCIENCE**

Nanomaterials are by definition small or composed of small structural or compositional elements. Establishment of structure-property relationships, crucially needed to advance the understanding and development of nanomaterials, requires, therefore, an ability to characterize structure, composition, and properties on the nanoscale. We will develop an infrastructure program designed to coordinate nanoscience research throughout the state, emphasizing our capacity to do research in the following areas:

- Nanostructured metals prepared by explosive synthesis for high strength structural components (NMT).
- Semiconductor and metal quantum dots and quantum dot arrays (NMSU, UNM, and SJC) prepared by self-assembly and heteroepitaxy for applications in optoelectronics, molecular electronics, energy conversion and catalysis.
- Biological, porous, and composite nanostructures (NMSU, UNM, and ENMU) prepared by molecular self-assembly for low k dielectrics, membranes, sensors, electrodes and the development of complex and collective functions like self-sensing and self-healing.
- Integration of nanostructured materials into devices and components (NMT and SJC).
- Thin films for electronic, magnetic, optical and wear applications (UNM, NMT, and NMSU).

In addition to academic research, integration of nanostructured materials into micro-electro-mechanical systems (MEMS) will be pursued in collaboration with LANL and SNL, recognized world leaders in MEMS technologies. The proposed characterization and computational user facilities will provide support not only to *Nanoscience*, but also to both the *Natural Resource Analysis and Management* and the *Proteomics* thrusts of our NM EPSCoR program.

Technological breakthroughs often follow the discovery of new materials and new materials phenomena. Current exploration into nanostructured materials fueled by the National Nanotechnology Initiative promises continued materials discovery, and further development of qualitatively new functionality and unprecedented functional density. New Mexico universities must develop a new infrastructure for nanomaterials research. This infrastructure will result from a statewide coordinated effort focused on: 1) establishing distributed nanomaterials characterization user facilities linking universities, national laboratories, and industries, and 2) creating a virtual web-based laboratory for modeling/simulation of nanostructured materials.

Nanoscience education and outreach, and nanomaterials research objectives of NM EPSCoR align well with those of a proposed UNM-SNL-LANL Center for Integrated Nanotechnologies. NM EPSCoR will facilitate the coordination of monetary and personnel resources to create an exceptional program.

### **Establishing Distributed Nanomaterials Characterization User Facilities**

To understand and develop nanomaterials we must first establish structure-property relationships. Conducting this research requires appropriate instruments, including: various microscopes (high resolution TEMs, STMs, SEMs), scanning force microscopes (AFMs, IFMs), surface analysis tools (like Auger and XPS spectrometers), nano-indentors, diffractometers (XRD, SANS, SAXS) and specialized surface characterization probes like SNL's Atom Tracker. Nanoscience research equipment, facilities, operation, and maintenance cost more than a single institution can finance. NM EPSCoR will encourage continued cooperative funding.

### **Proposed Work**

We propose to develop a distributed statewide network of *User Facilities for Nanomaterials Characterization*. These facilities will:

- Acquire and strategically distribute new nanomaterials characterization tools that do not require extensive facilities development. We will upgrade and/or replace existing larger facilities to enhance function and performance, and to enable remote access or operation.
- Provide remote access and, where possible, remote operation of several major instruments such as: UNM's new field emission high resolution TEM, an SEM to be located at UNM, an STM to be

located at NMSU, SNL's Atom Tracker and scanning forces microscopes, and small angle scattering facilities at LANL. Remote access refers to real-time data acquisition from remote sites, enabling researchers to confer and collaborate with distant operators. Remote operation means that researchers at any participating institution could operate instruments exactly as would a local researcher.

- Conduct workshops and summer classes to teach students and researchers the fundamental physical and chemical principles associated with these instruments and to train users in standard and advanced operational techniques. The facilities' budgets will include salaries for operations and maintenance technicians, and costs for supplies, facilities, and support services. With a high quality collaborative user facility, we can cultivate clientele whose user fees (higher for industrial users) would sustain the facilities. NM EPSCoR support for materials science lab equipment at San Juan College, on the edge of the Navajo Nation, will improve a now-fledgling collaboration with local industry on the analysis of Reverse Osmosis membranes, thereby providing local training and employment for Native students.

### **Creating a Virtual Web-Based Modeling and Simulation Laboratory**

Nanostructured materials exhibit size-dependent properties qualitatively different from their bulk counterparts. To exploit these unique properties and to integrate nanomaterials into useful devices and systems, we must establish the relationships between processing and structure, and between structure, properties, and performance.

#### ***Proposed Work***

We will create a virtual, web-based *Laboratory for Modeling and Simulation* (LMS) of both nanostructure processing and properties. To promote statewide on-line involvement, LMS will acquire and distribute workstations along with user licenses for commercial simulation software. LMS will also disseminate research codes currently under development within the NM university and national laboratory systems. Examples of relevant developmental research codes include equilibrium Monte Carlo simulations of surfactant self-assembly in the presence of interfaces and compositional gradients, density functional theory to predict solvation forces and colloid stability, and electromagnetic modeling techniques such as finite difference time domain and rigorous coupled wave electromagnetic analysis.

LMS faculty will employ and supervise undergraduates to input research codes onto the LMS web and maintain a user "hot-line." Links to the user facilities network will provide access to nanomaterials structure databases and promote information exchange between theorists and experimenters. A user-friendly web environment will encourage greater statewide participation in modeling and simulation, thus advancing nanoscience research and education in New Mexico. This approach allows us to create critical mass in nanoscience, thereby addressing one of the barriers to progress in science and technology.

The statewide team collaborating on Nanoscience involves UNM, NMSU, NMT, NMHU, ENMU, SJC, LANL, and SNL. The 3-year budget for this project is ~\$2.1M from NSF and ~\$1.015M matching.

### **PROTEOMICS**

Building on genomics, proteomics provides a powerful set of tools for the large-scale analysis of gene function at the protein level. Broadly, proteomics applies all those tools that measure the expression, localization, assemblies, and functions of proteins. A competitive biotechnology infrastructure requires the analysis of proteins encoded by genes. The NM EPSCoR statewide initiative in proteomics will:

- Benefit ongoing and planned projects statewide in molecular biology, medicine, plant and animal genetics and physiology, environmental biology, biochemistry, metabolic engineering, and toxicology.
- Provide instrumentation for protein analysis, biocomputing for protein structure and protein assemblies, automation for high throughput screening, and visualization of protein assemblies in cells.
- Use regional education initiatives, distance education, and cyber-collaborations for educational purposes and scientific collaborations.
- Establish partnerships with commercial biotechnological ventures and biomedical initiatives in drug discovery and development.

### **Protein Identification**

For identification, proteins in a complex mixture are first resolved by 2D gel electrophoresis. Because of its increased sensitivity and throughput, mass spectrometry has essentially replaced the classical technique of Edman degradation for sequencing of amino acids. The two main approaches to mass spectrometric protein identification involve peptide mass mapping and sequence analysis of fragmented peptides. MALDI-TOF (matrix-assisted laser desorption-ionization-time of flight) instruments allow for the high-precision peptide mass measurement. Peptide masses can be easily searched against databases. Electrospray ionization tandem mass spectrometry (ESI-MS/MS) gives structural information. Isolated peptides, fragmented by collision in the MS, are then measured. Sequence stretches can be deduced from the mass differences between fragments ranked in order of size. This latter procedure can be used directly to search protein sequence and nucleotide databases.

#### ***Proposed Work***

We will set up two protein identification sites: in Albuquerque, using existing facilities at Lovelace Respiration Research Institute (LRRRI) and UNM for biomedical and environmental applications, and at NMSU for agricultural applications and support for other NM institutions. Statewide use of the NMSU facility will justify technical support; state-of-the-art MALDI-TOF and MS/MS instrumentation; and gel, imaging, and chromatography systems. Biomedical use will require automated spot-picking and sample-handling at UNM.

Both microfluidic and nanotechnology approaches at LANL, SNL, and UNM have become relevant to protein separation and identification. SNL, for example, is developing mesoporous silica for 2D protein separation as well as nanoliter protein concentration. SNL's novel approach can create an opportunity through NM EPSCoR for materials sciences and proteomics biotechnology in New Mexico.

NM EPSCoR will build the research capacity of Diné College by supporting research into fundamental questions on how the presence of water affects the structure, dynamics, and function of proteins. Funding will provide essential Diné College laboratory equipment and supplies, and summer travel support for undergraduate students and faculty to work in the UNM proteomics lab.

#### **High Throughput Analysis of Molecular Assemblies**

A functional map of protein assemblies in cells can be based on mass spectroscopy analyses of protein complexes or on molecular tools such as the yeast two-hybrid screen. These techniques will be augmented by spectroscopic and calorimetric analysis of binding interactions of purified molecules. Several members of the NM EPSCoR proteomics team are associated with the National Flow Cytometry Resource or the Flow Cytometry Bioengineering Consortium at UNM and LANL. Flow cytometry aids in evaluating molecular interactions through assays of assembly, proteomics, and molecular evolution, yielding millions of assays per day. The chemical parameters used to characterize ligand-receptor interactions can be applied to families of drugs and targets in agricultural and biomedical problems. In addition, flow cytometry provides a general, low-cost approach for assembling complexes on particles that can be used in high throughput genomic or proteomic analysis. The assays are plate-based, small volume, and high sensitivity, and can be used for screening expression libraries for protein-protein interactions. Much of the intellectual property responsible for these advances is held by UNM or LANL, and commercial partnerships are already in place including licenses, research contracts, and collaborative federal grant awards. NM EPSCoR will leverage and expand this fledgling research infrastructure.

#### ***Proposed Work***

While existing grants support the development of high throughput approaches, the NM EPSCoR initiative would provide the infrastructure and technical support to convert these approaches into automated high throughput screens for on-line collaborative research and commercial applications statewide with national and international licenses. Robots that prepare samples in multi-well plates will be adapted for flow cytometry.

#### **Spatial and Temporal Proteomics in Cells**

A crucial endpoint of proteomics is defined at the cell and organ level where physiology is the product of molecular assemblies. A proteomics initiative can only be considered complete if cell data can be integrated with the molecular and analytical tools already described. Molecular assemblies are visible

in living cells by fluorescence microscopy and in fixed cells by electron microscopy. NM EPSCoR will take advantage of the UNM team of internationally recognized experts in fluorescence and electron microscopy already studying the topography, reorganization, and co-localization of molecules in cells.

#### ***Proposed Work***

NM EPSCoR will build on existing expertise with a statewide initiative and upgrades for live-cell confocal microscopy and skilled technical support for high-resolution transmission electron microscopy. With the appropriate labeling techniques, the spatial and temporal aspects of associations in cells and organs can be observed and reconstructed. Combined with biocomputing, our NM EPSCoR efforts on microscopy in proteomics will make it possible to determine whole cell or whole organ structural and functional models.

#### **Biocomputing of Molecular Assemblies and Bioinformatics for NM EPSCoR Proteomics**

As opposed to gene arrays and clinical samples, proteomics defines protein expression and function, and relates them to genomics studies. The proteins identified and the related pathways and protein networks become targets for drug discovery and therapeutics through molecular modeling and high throughput screening. Models can be used to identify and dock potentially active compounds that can be synthesized to test the computational predictions.

#### ***Proposed Work***

NM EPSCoR will encourage biomedical and computational researchers to collaborate in the arena of proteomics. Biology researchers are motivated by a desire to understand interactions that control protein function and drug-target interactions. Technological research efforts are enhanced by new technology invented at UNM and being commercialized for high throughput screening for molecular assembly. SNL is engaged in atomistic-scale modeling of biological molecules. NM EPSCoR efforts will utilize our broad array of molecular biophysics techniques, combined with the beyond-terascale computational capabilities (at SNL), to develop ideas for new, systematic, accelerated approaches to drug discovery. NM EPSCoR will facilitate a multi-institutional capability in protein structure, assembly, and networks that will apply state-of-the art chemical informatics and molecular biophysics methods (e.g. electronic structure and classical molecular simulation and theory including docking), implemented on massively parallel computing hardware, to the problem of molecular interactions.

The statewide proteomics team involves UNM, NMSU, NMT, ENMU, NMHU, SNL, LANL, Diné College, LRRI, and the National Center for Genome Resources. The 3-year budget for this project is ~\$2.1M from NSF and ~\$1.015M matching.

#### **HIGH PERFORMANCE CONNECTIVITY**

Increased research capacity requires higher performance network connectivity. We will create the nucleus of a New Mexico Computational Grid that will become part of a larger national grid, and eventually expand to include all New Mexico educational institutions, tribal colleges, and telemedicine sites. The NM EPSCoR focus areas commonly require high performance network connectivity for:

- Distributed storage of massive data sets that are conveniently accessible to collaborators, the national research community, and educational institutions for teaching and learning.
- Access to distributed high performance computational resources located within the state, at other universities, and national laboratories.
- Creation of a virtual web-based laboratory for analysis, modeling, simulation and visualization.
- Cyber-collaboration through a statewide and nationwide network for teleconferencing, collaboration and visualization.
- Development of multidisciplinary, multi-institutional education and outreach programs and the analysis and management of natural resources.

#### ***Proposed Work***

We will meet these needs by doubling the current bandwidth from one T1 line (1.5 Mbps) to two T1 lines (3 Mbps) for ENMU, WNMU and NMHU, providing a modest bandwidth increase of 5 Mbps (millions of bits per second) to the commodity Internet, and connecting New Mexico to *Internet 2* at OC-3

speed (155 Mbps) via the CHECSNet<sup>1</sup> router located at UNM. NM EPSCoR funding will allow all other New Mexico institutions to have access to *Internet 2*. An edge router at each of the six institutions will provide the interface between the Local Area Network of the institution and the Wide Area Network. Institutions will work together to seek state funding for continued connectivity beyond NM EPSCoR funding. The Chief Technology Officer of NMT, current president of the State Information Technology Commission, will seek a state allocation to ensure New Mexico schools have a viable State Network connected to all major national education and research networks.

The statewide high performance connectivity team involves UNM, NMSU, NMT, NMHU, ENMU, WNMU. The 3-year budget for this project is ~\$.9M from NSF and ~\$1.3M matching.

### **NEW MEXICO EPSCoR EDUCATION PROGRAMS**

Developing New Mexico's human intellectual capital is critical to the state, our stakeholders, and our future. Access to higher quality education, training, and research experiences for all New Mexicans will develop the human resource potential of the state.

Currently, we face some grim realities. Thirty nine percent of New Mexico's children under age 5 live in poverty. Twenty eight percent of our population is under 18 years of age, and 55% of these school age children receive free or subsidized lunches. In 2000, only 77% of the Hispanic students and 70% of the Native American students passed the 10th grade Competency Exam. Only 25% of all New Mexicans 18-24 years old are enrolled in college, and often they are not well prepared to handle college level courses. The majority of New Mexico's children, 49% Hispanic and 11% Native American, are strongly tied to their land and heritage. We must recognize potential second-language issues, first-generation college student status, and cultural ties if we wish to facilitate our children's education and employment future in their home state.

NM EPSCoR is committed to developing a statewide program within our focal research areas that will engage students in elementary and middle school, challenge them in high school, mentor them in relevant, cutting-edge research and learning communities as undergraduate and graduate students, provide them with financial incentives and support, and ultimately prepare them to enter New Mexico's developing, diverse, and competitive job market.

New Mexico colleges and universities participate in a variety of formal programs designed to recruit, develop, retain, and advance minority students into the science disciplines. These programs include NSF Alliance for Graduate Education and the Professoriat (AGEP) and NSF Alliance for Minority Participation (LSAMP). NM EPSCoR will collaborate closely with these programs to link minority students within our focal areas to the appropriate financial and mentoring support programs.

### **Proposed Work**

NM EPSCoR's education program will be based on recent research in teaching and learning, and best practices derived from years of NSF programs in New Mexico (SSI, RSI, CETP<sup>2</sup>). Our vision aligns closely with the vision and goals of both the New Mexico Commission on Higher Education and State Department of Education, which incorporate state and national standards in science, mathematics, and technology. The NM EPSCoR faculty and staff will establish a working relationship with teachers and students by collaborating with our state School-to-Work program's industry-education links, and with state and federal education programs. NM EPSCoR resources will enhance teacher/student preparation in cutting-edge nanoscience, biotechnology, and natural resource management.

The NM EPSCoR teacher/professional development effort will enhance the NMT Master of Science Teaching (MST) Program. This unique summer program provides practicing teachers with advanced science-teaching skills while they earn an MS degree. The program emphasizes content knowledge, intensive laboratory and field exercises, and recent advances in science and engineering. NM EPSCoR

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<sup>1</sup> CHECSNet (Council for Higher Education Computer/Communications Services Network) is an organization formed by the 3 New Mexico research institutions to provide more affordable and more effective Internet access to all institutions of higher education (public and private) in New Mexico.

<sup>2</sup> SSI-State Systemic Initiative; RSI-Rural Systemic Initiative; CETP-Collaborative for Excellence in Teacher Preparation.

will enable the MST program to provide innovative experiments and courses in nanoscience and proteomics/genomics. All NM EPSCoR focal area projects will provide internships at UNM and NMSU for high school students, teachers, and undergraduates, statewide. Pilot programs are being developed for Diné and San Juan Colleges and will be expanded to other colleges with significant Native American student enrollment.

### ***Natural Resources Education Programs***

NM EPSCoR will develop a *Virtual Center for the Environment* website targeting different grade levels (K-12) as it explores aspects of the environment ranging from hydrology to the natural history of plants and animals. Components will include: images and profiles of selected plants, fungi, and animals of New Mexico; photographs and descriptions of typical and important habitat types; long term records of temperature, precipitation, and stream flow from a subset of New Mexico locations; a searchable biodiversity database; information on identifying organisms in the field; information on the disciplines of hydrology, forestry, ecology, systematics, and evolution; natural history activities; information on forest fires and their effects on ecological communities and ecosystems; standards-based lesson plans; and interactive games that will foster an understanding of scientific principles. The *Virtual Center* website will be developed and maintained by staff of UNM's Centennial Science and Engineering Library, Museum of Southwestern Biology, and by biology educators (teachers and faculty) to be hired by UNM and NMSU. A web-design consultant will ensure that the overall design of the *Virtual Center* is inviting and functional.

We will develop an academic and workforce training program that equips students and professionals with advanced information technology skills and prepares them to meet the biological and ecoinformatics needs of business, state and tribal agencies, national laboratories, and statewide colleges and universities. Faculty at UNM, NMHU, LANL and SNL will begin to develop a full complement of interdisciplinary, inter-institutional upper-level undergraduate/graduate courses in ecoinformatics that will eventually be available via distance learning. NM tribal governments, in particular, need ecoinformatics training to initiate backfile conversion, storage, management, and mining of sensitive tribal environmental, health, and government data. Laguna Industries, Inc. of Laguna Pueblo will initially help develop the UNM ecoinformatics courses and workshops, ensuring that Native students have the training to fill critical, sensitive tribal jobs such as managing archeological and environmental sacred site data.

### ***Nanoscience Education Programs***

The MST program in nanoscience will be augmented by university summer workshops designed to introduce K-12 teachers and advanced high school students to nanotechnology, emphasizing the basic science and its application to the development of nanomaterials. These nanomaterials “chemistry sets” will allow students to explore molecular-based synthesis and phenomena, and prepare nanomaterials to be characterized remotely through our user facilities. These web-based characterization sessions would be complemented by age-appropriate descriptions of the experiments and the resulting nanomaterials structure, properties, and applications.

NM EPSCoR will develop a new graduate-level nanoscience program with faculty drawn from universities and national laboratories. The interdisciplinary nature of nanoscience research demands participation of faculty from diverse fields including chemistry, physics, materials science, engineering, biology, computer science, and medicine. Faculty will teach in interactive, video-linked, or web-based courses. San Juan College, on the edge of the Navajo Nation, will hold annual workshops for two-year college faculty on nanoscience equipment theory and use, allowing faculty to better attract and advise students, prepare students to transfer, and enhance their own instruction.

### ***Proteomics/Genomics Education Programs***

Graduate students will serve as TAs and collaborate with junior faculty. Each institution will develop proteomics course content. Using the present and improved distance education capabilities made possible by the NM EPSCoR high performance connectivity project, a monthly graduate level proteomics seminar series involving real-time broadcasts will provide interactive communication among students. These seminars will be taped to provide a body of reference material. The proteomics group will

partner with the New Mexico Science Teachers Association (NMSTA) leadership, holding facilitated meetings to produce well-informed, enthusiastic educational leaders able to direct the future of professional development in the areas of proteomics and genomics. Our goal is to influence and excite science educators regarding the potential for integrating cutting-edge scientific concepts into the framework of public school education. The annual proteomics meeting will encourage discussion of educational issues between scientists and educators. Summer internships for high school students in the labs at ENMU, NMHU and UNM will provide relevant experience. Inquiry-based experimental genomics activities for K-9 students will be developed. An *Informatics in Biotechnology* workshop will be offered for K-12 science teachers in conjunction with the State Science Fair; a university level workshop will travel to the various sites.

#### **VALUE ADDED AND SUSTAINABILITY**

NM EPSCoR will encourage college and university partnerships with private businesses and industry leaders to provide:

- Workforce training and job development programs to enable our citizens to obtain the knowledge and skills necessary to support new and better jobs in New Mexico.
- A concentration of intellectual capital that will generate new ideas, processes and technologies designed to develop the private sector in New Mexico's economy.
- Academic, research, and workforce training programs of exceptional and recognized quality.

Since the EPSCoR designation in January 2001, NM EPSCoR has already had a tremendous value-added effect on collaboration among the National Labs, university administration, and faculty. Universities have developed matches, largely from their internal budgets, as the first legislation that can be proposed for state support for NM EPSCoR will be January 2002. In addition to developing the required match, universities have committed to picking up most of the faculty/staff lines requested in this proposal as university lines following the 3-year NM EPSCoR funding period. This level of collaboration and commitment from universities has generated the appreciation and support of our legislators, the governor's Science Advisor, the Commission on Higher Education, and the Department of Economic Development, and will result in proposed legislation for state funding for sustained NM EPSCoR matches and project continuation in the future.

#### **Institute for Natural Resource Analysis and Management**

Designed with value added and sustainability as cornerstones, each component of INRAM links with an existing academic program or department. The leaders of these departments and programs view INRAM as important to continued growth and viability. The *biodiversity* aspect partners the state's Natural History museums to enable greater access to the data housed within each museum. This link among museums, as well as several new permanent hires, will enhance the museums' ability, individually and collectively, to compete for NSF funding and attract the support of individual donors. Moreover, the biodiversity database will create new opportunities for funding among a wide range of New Mexico's ecologists and evolutionists. The initiative in *remote sensing hydrology* will not only boost the Hydrology Program at NMT through the hire of a new assistant professor, but also will strengthen remote sensing hydrology across the state, thus enhancing the competitiveness of the state's hydrologists in this rapidly developing area. The *forestry* initiative will provide new infrastructure to the Department of Natural Resource Management at NMHU, coupled with the hiring of a tenure-track assistant professor, that will allow the department to compete more effectively for research funding in the area of forest ecology and management.

*The Laboratory of Environmental Chemistry* will provide every environmental biologist in the state with a state-of-the-art laboratory for analyzing soil, water, and biological samples. Properly trained researchers will be permitted to work in the laboratory on their own samples, asked only to reimburse the laboratory for consumables plus a small mark-up to help pay for service contracts and for eventual equipment replacement. Alternatively, samples may be dropped off for analysis and a fee paid for the service. We expect the laboratory to be sustained by these service fees as well as by direct support from

the Department of Biology at NMSU, which sees the laboratory as vital to the state's environmental research interests.

The *Laboratory of Environmental Spatial Analysis* will be fully integrated into the Geography Department at NMSU, which is committed to its long-term support. LESA will improve the department's ability to attract both collaborators and external funding, further ensuring the viability of the facility. Each INRAM affiliate recognizes INRAM's positive contribution and is committed to a lasting partnership.

### **Nanotechnology**

Due to the presence of two major national laboratories and a Department of Defense research laboratory, the Rio Grande Corridor is beginning to attract high technology industry start-ups and relocations. We fully anticipate that these industries will join our universities and federal laboratories in nanomaterials science and technology, leading to new materials-based technologies. The nanotechnology plan for sustaining the NM EPSCoR infrastructure improvements has many facets. The infrastructure improvements will provide New Mexico universities' nanotechnology researchers with increased opportunities to obtain external research and equipment grants. In turn, these new research grants may contain line items for materials characterization and upgrades as applicable. Each of the universities participating in the NM EPSCoR nanotechnology program will use infrastructure seed funding to explore and develop new nanoscience and nanomaterials opportunities leading to new research proposals to NSF and other external agencies. The proposed nanoscience and nanomaterials program will be sustained, beyond the NM EPSCoR funding period, in significant part by the increased student enrollment and the creation of the new nanoscience faculty lines and nanotechnology programs.

We also anticipate support for the state's nano program from industrial sponsors of the UNM/Rutgers Ceramic and Composite Materials Center, CCMC. This association will not only provide industrial insight and research fund leveraging, but will also encourage support from other industries. Already, significant research collaboration on nanoscience and nanomaterials exists between our national laboratories and universities. These already-established nanoscience programs will provide the foundation for new NM EPSCoR nanotechnology programs.

### **Proteomics**

The natural continuum between proteomics and genomics is enhanced by our NM EPSCoR efforts. The commercial biotechnology enterprise, represented by the New Mexico Biotechnology and Biomedical Association ([www.nmbio.org](http://www.nmbio.org)), includes several dozen companies whose work relates to the proteomics initiative. We have recently begun to involve national laboratories in high throughput proteomics with the NIH National Flow Cytometry Resource at LANL and in molecular modeling and informatics with the Computing Center at SNL. UNM and SNL are pursuing a Bioinformatics Institute for proteomics and genomics. Historically, shared facilities at UNM, that include the proposed proteomics capabilities, receive support from user fees and the institution. The high throughput technologies and real-time proteomics will be available to NSF EPSCoR users without charge. At the end of the current funding, modest user fees in conjunction with institutional support will sustain the facilities. At NMHU the Principle Investigators currently on externally/federally funded grants would use the improved infrastructure to garner future external funding.

At NMSU, during the NM EPSCoR grant period, a full-time technician will run the Mass Spectrometry-based Proteomics resource to be located in the Molecular Biology Core Facility. To sustain the proteomics facility beyond the term of the NM EPSCoR grant, we plan to include fees for services and institutional support (to be negotiated) for the technician salary, using the Electron Microscopy Laboratory at NMSU as a model. Further, the NMSU Department of Chemistry and Biochemistry will attempt to hire a new faculty member experienced in Mass Spectrometry to leverage the facility with new faculty research initiatives and collaborative grant efforts in open competitions. Successful efforts in these open competitions will generate both fees and partial salary lines to sustain the facility. Each university participating in the NM EPSCoR proteomics program will use infrastructure seed funding to explore and develop opportunities leading to new research proposals to NSF and other external agencies.

### **PROJECT TIMETABLE AND MILESTONES**

## **Institute for Natural Resources Analysis and Management**

**Year 1:** Undertake national searches for tenure-track and research faculty at NMSU, NMHU, NMT and UNM. Hire administrators, technicians, and specialists to staff LESA, LEC, and the Natural History museums. Begin to organize hydrology remote sensing data sets and groundtruthing. Begin constructing database for natural history collections. Purchase equipment for LEC and LESA. Complete prototype web page designs.

**Year 2:** Complete faculty hires; completely staff laboratories and museums. Make georeferenced hydrology remote sensing products through LESA. Continue data entry for all natural history collections and make it available on-line. Finalize web page design and accessibility (through LESA) for the *Center for the Environment* site. Continue hydrology groundtruthing. LEC operational and capable of stable isotope analysis. External board review of INRAM project.

**Year 3:** Complete specimen data entry from natural history museums and make it available on-line. Hydrology RS products available through LESA, updated as new data are collected. LEC fully operational and capable of quantification and identification of organic compounds from soil, water, and biological samples. Proposal development for independent funding.

## **Nanoscience**

**Year 1:** Instrument selection and distributive network installation. Outreach Program initiated. Trial teacher training programs initiated. Hold planning meeting for the prospective statewide nanoscience faculty. Survey nanoscience/nanomaterials research and development in New Mexico.

**Year 2:** Remote access to UNM TEM, LANSCE on-line. Summer TEM and LANSCE on-site training programs completed. Initiate remote access to UNM FESEM and NMSU STM. Plans formulated for full-scale teacher training and K-12 interactive programs. K-12 student workshops. Full-scale implementation of summer teacher training programs. Curriculum development and trial courses in place for fall semester. Nanoscience project review by external technical board.

**Year 3:** FESEM and STM on-line. Initiate remote access program to other instruments. All selected characterization facilities on-line and functioning. Summer teacher-training program; K-12 student workshops. Expanded curriculum program for spring semester. Nanoscience proposal development for independent funding.

## **Proteomics**

**Year 1:** Purchase 2D gel systems; perform protein separations on 2D gels, spot comparisons and identification, and isolation and purification. Set up molecular assembly capabilities and robotics capabilities. Recruit graduate and undergraduate assistants and UNM faculty. Initiate statewide mentoring and faculty development relationships. Develop statewide proteomics seminar series. Establish courses at each institution, conduct workshops, and start the annual proteomics conference series. Align the state's human resources through interactions and collaborations with state leaders in education, medicine, science, business, and industry. Enable NMSTA participation in annual proteomics conferences.

**Year 2:** Purchase mass spectrometry equipment and robotics; installation and networking; scale up sample throughput, and test analysis software and networking issues. Begin processing statewide samples. Bring real-time proteomics and biocomputing on-line. Fill in equipment gaps at other institutions. Implement mentoring relationships for faculty development, identifying targets for research grant applications. Implement statewide seminar series. Share educational components that have been successful. Post educational materials at Proteomics website. Leverage the state resources and create a statewide plan for moving forward for professional development. Address specific issues in teaching *Biology of the Future* with K-12 teachers. Form regional partnerships between scientists and educators. External technical board reviews proteomics project.

**Year 3:** De novo protein sequencing on MS/MS system and creation of peptide fingerprint databases from MALDI-TOF data. Provide integrated proteomics services and collaborations statewide. Prepare and submit applications for subsequent broad-based programmatic funding from targeted state, federal, and private resources for research and professional development. Conduct training workshops, mentoring programs, and proteomics conference series. Proposal development for independent funding.

## **High Performance Connectivity for New Mexico Institutions**

**Year 1:** Upgrade of the CHECSNet *Internet 2* router at UNM completed by NM EPSCoR grant start date. UNM, NMSU and NMT connected to *Internet 2* and fully operational using new router 1 week after NM EPSCoR grant start date. Additional lines ordered for ENMU, WNMU and NMHU 1 week after NM EPSCoR start date. ENMU, WNMU and NMHU bandwidth to *Internet 1* and *Internet 2* doubled and fully operational 3 months after NM EPSCoR start date. All NM postsecondary institutions have access to *Internet 1* and *Internet 2* six months after NM EPSCoR grant start date.

## **NM EPSCoR ORGANIZATIONAL STRUCTURE AND MANAGEMENT PLAN**

The ultimate responsibility for NM EPSCoR rests with the New Mexico Council of University Presidents (CUP). As the fiscal institution, UNM maintains the state NM EPSCoR Office and holds the Office of State Director. The State Steering Committee reports to the CUP and consists of 6 university VPs for Research, 1 representative for two-year and tribal schools, 1 representative from each of LANL and SNL, the Science Advisor for the Governor's Office, a representative from the State Department of Education, 2 state legislators, 2 representatives from large and small private industry, and 1 from Innovative Technology Partnerships, LLC, a high-technology consulting group that helps companies assess their business posture and technology literacy. The Office of Chair of the State Committee is located at NMT. Ex-Officio (non-voting) members on the State Committee are the State Director and external advisors from other EPSCoR states, currently Vermont (Chris Allen), Wyoming (William Gern) and Oklahoma (Lee Williams). The State Committee evaluates technical reviews of projects/proposals for balance and state needs, provides general guidance on statewide NM EPSCoR projects, serves as an advisory body to the CUP on the selection focus areas and proposals in those focus areas. Sub-committees are formed as needed to deal with administrative and science and technology matters.

### **Project Director and Co-Director**

The primary management team for NM EPSCoR consists of the State Director (Dr. James R. Gosz) and Co-Director (Barbara Kimbell) located at UNM. The State Director reports to the State Committee and occupies a position within the Office of the Vice-Provost for Research at UNM.

#### ***The State Director's Responsibilities***

- Coordinate and oversee all state NM EPSCoR programs and serve as the principal investigator on proposals to the NSF EPSCoR program.
- Serve as primary liaison between NM EPSCoR and its external constituencies, including federal and state legislative offices, NSF, NM EPSCoR State Committee, NM EPSCoR Foundation, NM EPSCoR Coalition, state, federal, and tribal agencies, and other NM EPSCoR programs.
- Direct, oversee and coordinate activities of the NM EPSCoR offices, including agency and cost-sharing budgets; working with state officials to maintain support and funding of NM EPSCoR to meet matching requirements; work with the NM EPSCoR State Committee and the CUP to focus academic research to respond to the needs/opportunities in New Mexico.
- Coordinate efforts with state higher education leadership (public and private) to develop strong academic programs for NM EPSCoR support; oversee quality and timely communications of announcements and events related to NM EPSCoR activities.
- Represent the program at national, regional, and state meetings.

#### ***The Co-Director's Responsibilities***

- Report to the State Director and occupy a position within the Office of the Vice-Provost for Research at UNM.
- Assist the State Director in all aspects, paying special attention to collaborative initiatives between NM EPSCoR and statewide educational programs.
- Direct the organization of the annual statewide conferences held in a different city each year. The annual conferences will vary their themes to address three primary audiences: scientists, state legislature, and industry partners.
- With the State Director, represent the program at national, regional, and state meetings, and may assume program responsibilities in the absence of the State Director as assigned.

The NM EPSCoR management will convene quarterly conference calls among the project directors and semiannual site visits to each participating institution to insure that project milestones, timelines, and financial obligations are being met. Sub-awards will be reviewed quarterly to allow sufficient time to analyze budget expenditures and reallocate unexpended resources if needed. NM EPSCoR will continuously collect information, modeled after other EPSCoR state systems, to evaluate progress for each project, compile statewide data needed for reporting, and maintain the NM EPSCoR website. Based on this information, the State Director will report progress and make recommendations for corrective actions to the State Committee at their quarterly meetings. The State Director and Chair of the State Steering Committee will report a semiannually to the CUP. The 3-year budget for the administration of the NM EPSCoR program is ~\$.9M from NSF with ~\$.5M matching.

#### **External Evaluation**

A separate external (out-of-state) technical board will evaluate each project during the second year of their award for progress and scientific merit. Using that review, each project will develop a strategic plan in the third year for independent funding to sustain the project or a renewal effort in a subsequent NM EPSCoR infrastructure proposal. In all cases, a project will not receive more than 6 years of NM EPSCoR infrastructure support. AAAS will review the entire NM EPSCoR program in the third year of the award.

#### **Closing Remarks**

NM EPSCoR has stimulated unprecedented interaction and collaboration among state institutions as we have examined the academic system, the barriers constraining our research funding competitiveness, and our ability to develop cutting-edge research and educational opportunities. With NM EPSCoR infrastructure funding, close inter-institutional collaboration (among education, industry, and national laboratories) will spread strength across the state, increasing our capabilities in our focus areas: *Natural Resources Analysis and Management*, *Nanoscience*, and *Proteomics*. We can leverage this cooperative interaction to make New Mexico a more competitive force in the future of scientific discovery and achievement.